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4 April 2000

Ramsey Russell
Mississippi Wetlands Management District
Tallahatchie National Wildlife Refuge
U.S. Fish and Wildlife Service
16736 Highway 8 West
P.O. Box 1070
Grenada, MS 38902-1070

Dear Ramsey,

Thanks for your cooperation in our research project to establish shrubs and small seeded trees from seed. You will find enclosed a summary report detailing our implementation on 4 study sites. As indicated in the report, we will attempt to ascertain how successful we were after 18 months (circa November 2001).

If your have any questions please contact me at the above e-mail or phone.

Sincerely,

Daniel J. Twedt
Wildlife Biologist

Establishment of shrub and tree habitats on cleared bottomland sites from seeds.

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Forest restoration on bottomland sites is ongoing through out the Mississippi Alluvial Valley. Because restoration of bottomland hardwood forests has historically focused on heavy-seeded mast-producing species that are slow to develop, early successional grassland and shrub habitats are currently widespread in this floodplain. Some birds of management concern (e.g., Bell's Vireo, Orchard Oriole, and Painted Bunting) breed in scrub-shrub habitats. Many other species of forest breeding birds use shrubby areas post-breeding (Kilgo et al. 1999). Indeed, for some species, shrub-scrub habitat may be critical during the development of juvenile birds (Vega Rivera et al. 1998). Furthermore, shrubby habitat often provides an important food source, in the form of soft, fleshy fruits, for migrating and wintering songbirds.

However, many reforested sites are isolated within agricultural landscapes. This isolation limits natural invasion by woody species and, because only a few heavy-seeded species are typically planted, species that produce soft, fleshy fruits or small seeds that are readily consumed by passerines may be lacking. Thus, the scrub/shrub habitat currently available on reforested sites may be sub-optimal for migratory birds. Furthermore, because of their isolation, a suitable

management strategy for some of these sites (e.g., some remote FmHA tracts) may be to maintain these areas in early successional habitat. Maintaining a shrubby "disclimax" community would avert the creation of small isolated forest patches that may function as "population sinks" for forest breeding birds -- where recruitment is less than survival.

To increase the suitability of restored bottomland sites for wildlife, particularly for birds, I attempted to establish soft, fleshy-fruited and small seeded woody species on agricultural fields that were scheduled for reforestation. I chose to use seed stocks as the primary method of restoration because only a few species of shrubby plants are readily available as seedling stocks, and because of the greater time and expense of planting 1-0 seedlings (Allen et al.2000). Seeds of many shrubby and small seeded tree species are available from commercial seed suppliers in Louisiana, Missouri, and Tennessee. Furthermore, Twedt and Wilson (in review) suggested that wildlife (birds) benefited more from reforestation using direct seeded acorns than from reforestation using planted 1-0 oak seedlings.

Unfortunately, except for planting of acorns and pecans, little information is available on the methodology or success of directly sown seeds on bottomland sites. Although Allen et al. (2000) state that direct seeding of light seeded species has been unsuccessful in the Mississippi Alluvial Valley, no data or studies are cited to verify this claim. However, Chris Best (Lower Rio Grande Valley NWR) found direct seeded shrubby species were generally unable to compete with invasive exotics within the Lower Rio Grande Valley (Twedt et al. in press). Conversely, Holt (1998a, 1998b)) found that direct sowing of seeds was successful at restoring shrubland in Australia. I view this restoration study as an opportunity to provide baseline empirical data on the rates of establishment and survival of shrub and small-seeded tree species when generically applied to bottomland sites. However, because each species has unique environmental requirements for

germination and subsequent survival, I am confident that species-specific pre-planting seed preparation and informed matching of seeds to edaphic and hydrologic conditions would increase germination and survival. For this generic application, I have chosen methods of establishment that were easily applied with a minimum of equipment and labor. I applied these methods to treatments that are intended to promote shrub-scrub habitat as a transient habitat in restoration of bottomland hardwood forests as well as treatments that promote shrub-scrub as the dominant habitat such that, theoretically, shrubs may be perpetually maintained through cyclic perturbations (e.g. at 10-year intervals).

Methods —

Study locations – Three primary study sites were selected based on responses to a solicitation to National Wildlife Refuge (NWR) personnel for "clean" (disked or last season's crop residue) sites of >3 ha (~8 acres). Actual study sites used were 7.5 ha sites at Bayou Cocodrie NWR, Louisiana (Fig. 1); Mollicy Farms, Louisiana (Louisiana Wetlands Management District; Fig. 2); and Tallahatchie NWR, Mississippi (Mississippi Wetlands Management District, Fig. 3). I also seeded an additional (secondary) 7.0 ha study site at Cache River NWR, Arkansas (Fig. 4) that had been previously planted to oaks following traditional reforestation practices.

Restoration methods – Six restoration treatments (5 treatments + control) were applied at 2 intensities (high and low) using a split plot experimental design at each of the 3 primary (7.5 ha) study sites. Treatments were: (1) seeds of shrubby plants; (2) seeds of shrubby plants combined with seeds of hard and soft mast producing trees; (3) seeds of shrubby plants combined with planted seedlings of hard mast producing trees (Nuttall oak, *Quercus nuttalli*); (4) seeds of only hard and soft mast producing trees; (5) only planted seedlings of hard mast producing trees (oaks); and (6)

unplanted, non-seeded control. Areas within the same fields that were planted with tree seedlings by Refuge staff using traditional reforestation methods will serve as an additional "control" sites.

Two plots of each treatment were applied at each study location (Figs. 1-3), 1 at a high rate of seeding (planting) the other at a lower rate. To achieve desired densities of sown seeds of circa 400 g / ha (low) and >1000 g / ha (high), treatments were applied to either 0.5 ha or 1.0 ha plots. Seeding rates were based on recommendations of Holt (1998b) of 400 to 1000 g / ha of pure live seed (PLS). As I did not test seed viability, I generally exceeded Holt's recommended rate to account for nonviable seed. Additionally, 10% of treatments 1, 2, 3, and 4 on primary study sites (Figs. 1 – 3) were treated with soil mycorrhiza (Endo Net Bulk Granular Mycorrhizal Inoculum, Reforestation Technologies International, Salinas, CA, www.reforest.com).

Seeds were mixed with pelletized limestone (as a physical carrier) and directly sown on sites using a cyclone spreader affixed to an ATV. Mycorrhiza were also broadcast from this cyclone spreader. Although we attempted to incorporate seeds and mycorrhiza into the soil using a wooden drag and small garden disk, lack of adequate equipment and/or wet field conditions prevented incorporation of seeds and mycorrhiza into the soil. Thus, most seed remained on soil surface. However, as rain occurred within a few hours or at most a few days after seeding at primary sites, seeds most likely were in adequate contact with the soil and soil moisture.

Seeds of 23 shrub species (Table 1) and seeds of 18 tree species (Table 2) were sown. Seeding rates varied slightly among study sites (Tables 1 & 2). The high rate of seeding shrubs ranged from 870 to 1250 g / ha, the low rate of seeding shrubs ranged from 310 to 400 g / ha, the high rate of seeding trees was 1385 – 2350 g / ha, the low rate of seeding trees was 418 – 890 g / ha. All seedlings planted were 1-0 stock Nuttall oak. Seedlings were planted at a high rate on 10 x 10 m spacing (100 seedlings / ha) and at a low rate on a 12 x 15 spacing (56 seedling / ha).

Following the recommendations of Allen (1997) and Twedt and Wilson (in review), I specifically chose a planting density that was far less than the 500-750 stems / ha normally seeded. This reduced tree density is intended to provide open inter-tree spaces for invading woody trees and shrubs.

Most seed was obtained from Louisiana Seed Company, Lecompte, LA or Lovelace Seed Company, Elsberry, MO. Two species were ordered from Sheffields Seed Co, Looke, NY, whereas 4 species were locally collected. Cost of tree seed was <$14 / ha at low density and $65 / ha at high density. Cost of shrub seed was <$25 / ha at low density and $43 / ha at high density.

Site and planting conditions —

The Bayou Cocodrie NWR site (planted 10-11 Feb 2000) was last year's sorghum field that had been lightly disked in the fall. Crop residue remained in clumps throughout the site. Soil moisture was low which hindered planting tree seedlings. A power line transected this site.

The Mollicy Farms site (planted 18, 21 Feb 2000) was a well disked (rice?) field with sparse vegetative cover. Soil moisture was adequate to high with standing water along the field margins. Rain occurred within 1 hour of sowing seeds. These rains delayed planting of oak seedlings, which were not planted until 3 days later.

The Tallahatchie NWR site (planted 23 Feb 2000) was also a lightly disked former sorghum field with some vegetation residue on the soil surface. Soil moisture was adequate for planting seedlings. Rain occurred at this study site within 4 hours after planting. A power line transected this site.

The Cache River NWR site (planted 24 Feb 2000) was part of a 85 ha (182 acre) field that had been entirely planted with seedlings of 9 tree species (Nuttall oak [2400 seedlings], willow oak

[3100],water oak [4600], cherrybark oak [6900], overcup oak [6300], cow oak [1100], sweet pecan [2225], green ash [1200], sweetgum [4100]) of at a density of 750 seedlings / ha (302 / acre) approximately 1 month prior sowing of seeds in this study. This field was last years soybean stubble that had not been disked. Green vegetation was abundant, albeit very short (<2 cm) throughout this site.

Future Evaluation —

I hope to visit these sites to visually assess seed germination during the summer of 2000. However, a systematic sampling to assess germination of shrubs and trees, and their subsequent survival and growth, will not be undertaken until late summer or fall of 2001 (circa 18 months after planting). Each level of treatment will be assessed using a series of 2.52 m radius (20 m^2) circular plots. Using data only from the area of plots not treated with mycorrhiza (90% of plots), mean stem density and species richness will be compared among study sites, planting intensities (high, low), and the 6 planting treatments using a split-split plot analysis of variance (ANOVA). Multivariate ordination procedures will be used to compare relative stem densities of species among all sample units. Mean stem density and mean plant height will be compared between mycorrhiza and non-mycorrhiza plots using a paired t-test.

Literature Cited —

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Allen, J. A., B. D. Keeland, A. F. Clewell, and H. E. Kennedy, Jr. 2000. A guide to bottomland hardwood restoration. Biological Report, U.S. Dept. Int. (in press).

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Kilgo, J. C., K. V. Miller, and W. P. Smith. 1999. Effects of group selection timber harvest in bottomland hardwoods on fall migrant birds. Journal of Field Ornithology 70:404-413.

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Twedt, D. J., R. R. Wilson, C. Best, S. Schweitzer, P.B. Hamel. 2000. Habitat restoration for conservation of migratory landbirds: species and local issues. In R. J. Cooper (ed.) Partner-in-Flight Workshop, Management of Migratory Landbirds of the Southeast: State of Knowledge and Research Needs, 28 - 29 January 1999, Biloxi, Mississippi. (in press).

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Timetable	**(Year; Month)**
Locate study locations	FY2000; Dec-Feb
Obtain seed	FY2000; Dec-Jan
Plant sites	FY2000; Feb-Mar
Assess 2nd year shrub and tree survival	FY2001; Nov
Assess 4th year shrub and tree survival (?)	FY2003; Nov

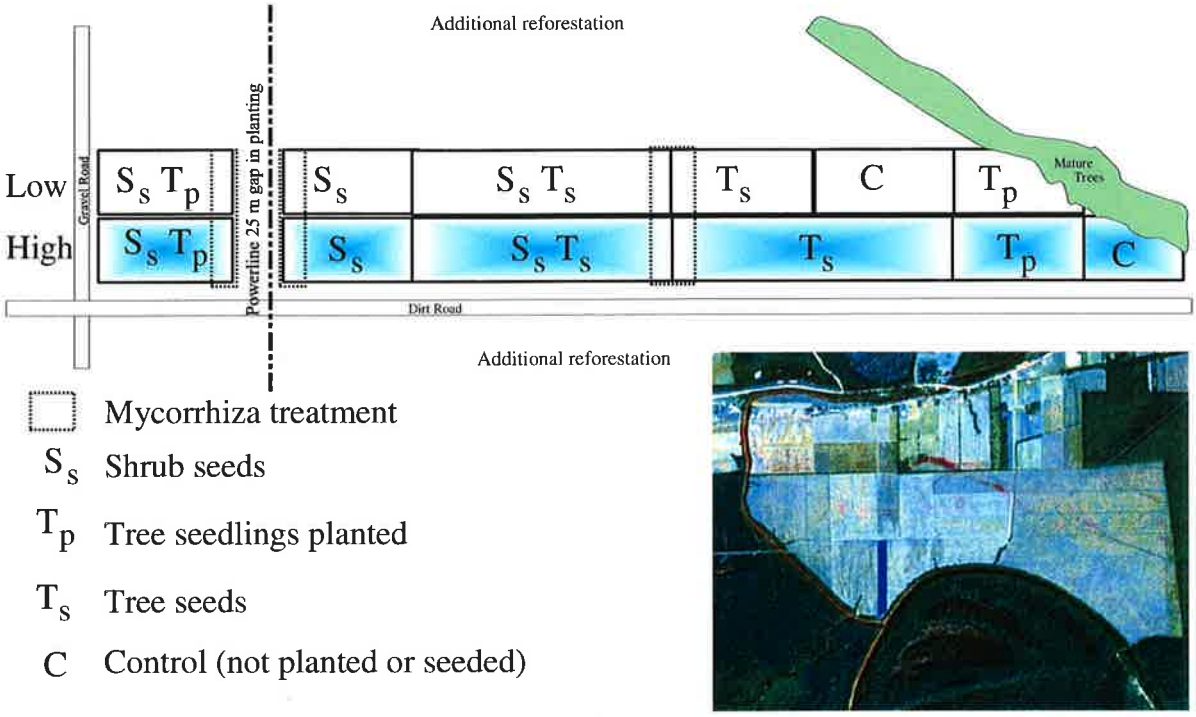


Figure 1. Shrub establishement study location at Bayou Cocodrie National Wildlife Refuge, Concordiia Parish, LA planted 10-11 February 2000

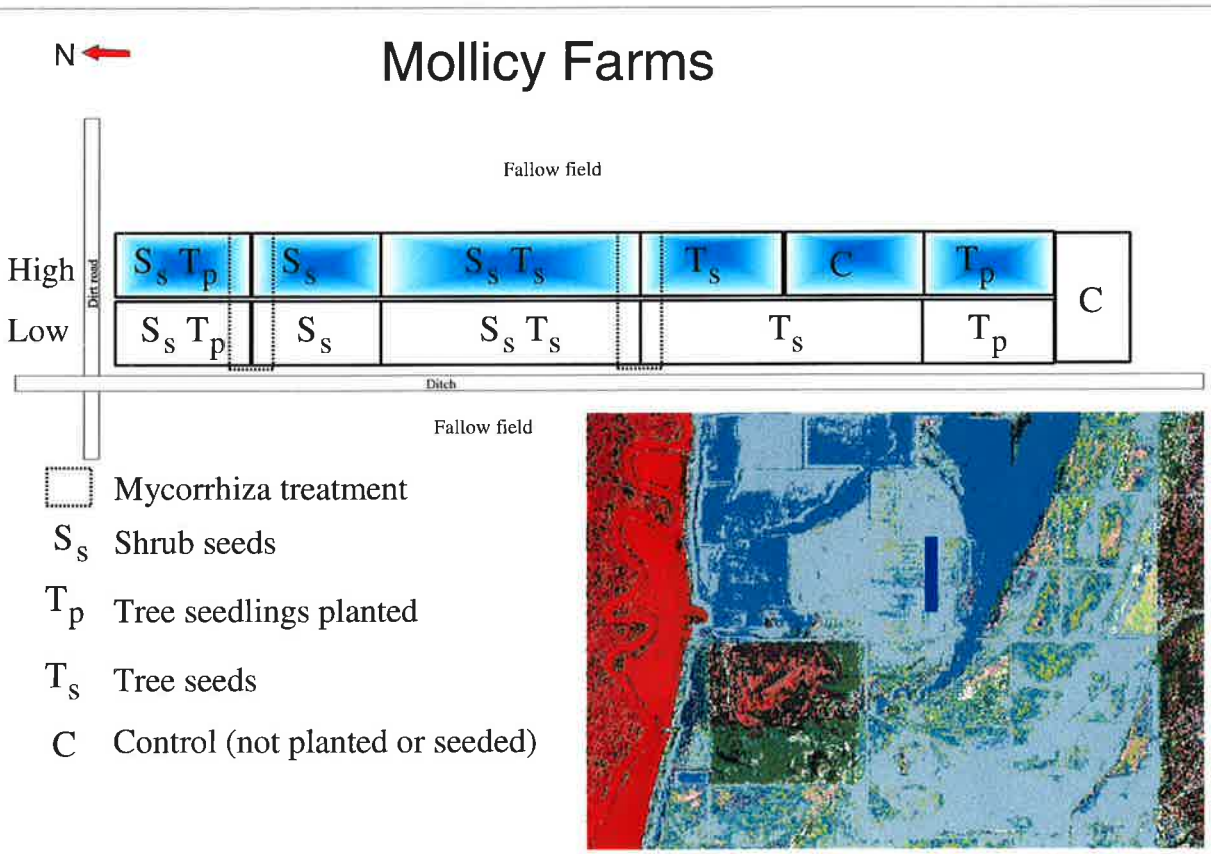
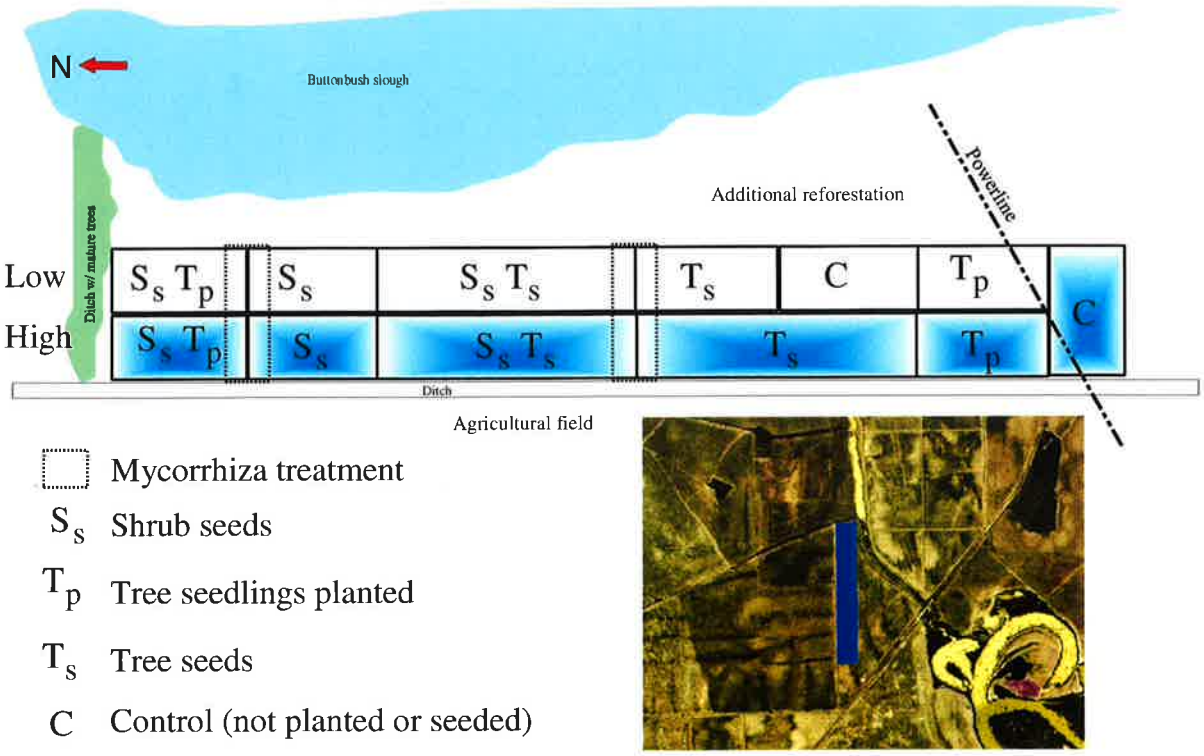


Figure 2. Shrub establishement study location at Mollicy Farms, Louisiana Wetlands Management District, Morehouse Parish, LA planted 18, 21 February 2000

Tallahatchie NWR



Mycorrhiza treatment

S_s Shrub seeds

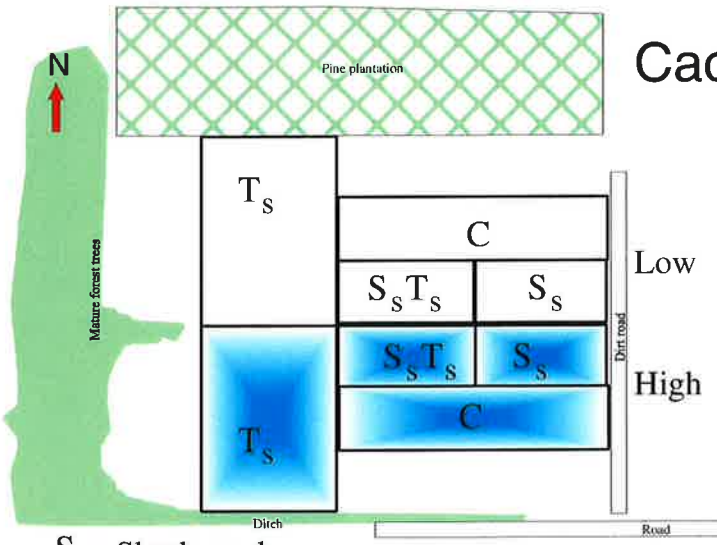
T_p Tree seedlings planted

T_s Tree seeds

C Control (not planted or seeded)

Figure 3. Shrub establishement study location at Tallahatchie National Wildlife Refuge, Tallahatchie County, MS planted 23 February 2000

Cache River NWR



S_s Shrub seeds

T_p Tree seedlings planted throughout site

T_s Tree seeds

C Control (not planted or seeded)

Figure 4. Shrub establishement study location at Cache River National Wildlife Refuge, Woodruff County, AR planted 24 February 2000

Table 1. Species, cost, and rates of seeding for shrubs and small fruiting trees.

						BayouCocodrie NWR				Mollicy Farms				Tallahatchie NWR				Cache River NWR			
			Price	Cost / ha	Cost / ha	grams seed / ha		# seeds / ha		grams seed / ha		# seeds / ha		grams seed / ha		# seeds / ha		grams shrub seed		# shrub seeds	
Species	Common name	seeds / g	$ / kg	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Amorpha fruiticosa (s)	Indigo bush (False indigo)	9.0	$41.80	$2.66	$0.75	60	16	543	140	48	16	430	140	48	16	430	140	40	10	362	90
Aralia spinosa	Devils walking stick	45.2	$154.00	$8.59	$3.54	50	20	2,262	905	33	20	1,471	905	33	20	1,471	905	58	12	2,624	543
Asimina triloba	Pawpaw	0.2	$47.30	$2.58	$0.83	50	15	11	3	35	15	8	3	35	15	8	3	48	10	11	2
Callicarpa americana	American beauty berry	14.1	$213.40	$3.73	$1.39	18	4	247	57	13	4	177	57	13	4	177	57	10	10	141	141
Cephalanthus occidentalis	Buttonbush	56.6	$37.40	$2.24	$1.03	52	25	2,913	1,414	38	25	2,121	1,414	38	25	2,121	1,414	62	10	3,507	566
Cornus ammion	Silky dogwood	4.5	$33.00	$1.90	$0.65	55	16	249	72	43	16	192	72	43	16	192	72	35	15	158	68
Cornus florida (L)	Flowering dogwood	2.3	$33.00	$0.00	$0.00	23	0	51	0	15	0	34	0	15	0	34	0	20	10	45	23
Cornus stricta	Swamp dogwood	5.4	$66.00	$3.63	$1.49	52	20	282	109	42	20	228	109	42	20	228	109	32	10	174	54
Crataegus aestivalis	Mayhaw	9.0	$110.00	$5.61	$3.11	50	22	452	199	37	22	335	199	37	22	335	199	30	25	271	226
Crataegus marshallii	Parsley hawthorn	4.5	$132.00	$8.28	$3.96	58	28	260	127	46	28	206	127	46	28	206	127	45	8	204	36
Halesia diptera	Two-winged silverbell	0.7	$41.80	$2.93	$1.72	65	38	47	27	48	38	34	27	48	38	34	27	55	15	40	11
Ilex decidua (cs)	Deciduous holly	13.6	$41.80	$3.66	$1.36	63	13	848	170	63	13	848	170	63	13	848	170	100	80	1,357	1,086
Ilex decidua (db) (L)	Deciduous holly	6.8	$0.00	$0.00	$0.00	33	0	221	0	25	0	170	0	25	0	170	0	15	10	102	68
Ilex decidua (fb) (L)	Deciduous holly	4.5	$0.00	$0.00	$0.00	250	75	1,131	339	218	75	984	339	218	75	984	339	65	0	294	0
Malus angustifolia	Southern crabapple	2.8	$165.00	$3.18	$0.17	18	0	49	0	14	0	38	0	14	0	38	0	15	4	42	11
Morus rubra	Red mulberry	28.3	$165.00	$1.65	$0.62	10	3	283	71	8	3	212	71	8	3	212	71	5	5	141	141
Prunus virginiana	Chokecherry	3.6	$17.60	$0.93	$0.48	50	24	181	87	38	24	138	87	38	24	138	87	35	12	127	43
Pyrus communis	Common pear	2.3	$88.00	$1.10	$0.22	13	2	28	3	10	2	23	3	10	2	23	3	5	4	11	9
Rhus copallina	Flameleaf summac	24.9	$22.00	$1.30	$0.44	55	18	1,369	436	42	18	1,045	436	42	18	1,045	436	42	10	1,045	249
Rhus glabra	Smooth summac	22.6	$33.00	$1.86	$0.70	55	18	1,244	396	45	18	1,018	396	45	18	1,018	396	25	15	566	339
Sabal minor	Cabbage palmetto	0.9	$33.00	$2.21	$0.42	63	9	57	8	47	9	42	8	47	9	42	8	50	15	45	14
Sambucus nigra (s)	Elderberry	79.2	$37.40	$1.95	$1.03	50	25	3,959	1,980	41	25	3,247	1,980	41	25	3,247	1,980	27	10	2,138	792
Viburnum rufidulum	Rusty blackhaw	1.7	$74.80	$5.05	$1.01	63	11	106	19	48	11	81	19	48	11	81	19	50	10	85	17
				$65.03	$24.90	1,251	399	16,796	6,561	991	399	13,081	6,561	991	399	13,081	6,561	869	310	13,492	4,531

cs = clean seed, db = dried berries, fb = fresh berries, L = locally collected seed, s = Sheffield Seed Company

Table 2. Species, cost, and rates of seeding for light-seeded and heavy-seeded trees.

		Weight and cost				BayouCocodrie NWR				Mollicy Farms				Tallahatchie NWR				Cache River NWR			
		weight	price	cost / ha	cost / ha	grams seed / ha		# seeds / ha		grams seed / ha		# seeds / ha		grams seed / ha		# seeds / ha		grams seed / ha		# seeds / ha	
Species	Common name	seeds / g	$ / kg	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Acer rubra (2)	Red maple	5.88	$44.00	$1.86	$0.61	35	10	206	59	23	8	137	44	23	8	137	44	26	13	153	74
Albizia julibrissin (L)	Mimosa	2.26	$0.00	$0.00	$0.00	15	0	34	0	10	0	23	0	10	0	23	0	10	8	23	17
Celtis laevigata	Sugarberry	3.85	$55.00	$3.35	$1.33	50	24	192	92	37	18	141	69	37	18	141	69	35	13	135	48
Diospyros virginiana	Persimmon	0.81	$17.60	$2.49	$0.44	120	20	98	16	93	15	76	12	93	15	76	12	70	20	57	16
Fraxinum pennsylvanica	Green ash	11.31	$33.00	$2.67	$0.22	68	0	764	0	57	0	641	0	57	0	641	0	38	14	424	153
Fraxinus profunda (2)	Pumpkin ash	5.43	$41.80	$1.04	$0.57	21	17	111	90	17	13	90	68	17	13	90	68	13	3	68	14
Gleditsia triacanthos	Honey locust	1.27	$27.50	$3.99	$1.23	125	35	158	44	90	26	114	33	90	26	114	33	75	38	95	48
Gleditsia triacanthos (L)	Honey locust	1.27	$0.00	$0.00	$0.00	65	0	82	0	50	0	63	0	50	0	63	0	60	0	76	0
Liquidambar sytraciflua	Sweetgum	9.05	$92.40	$6.95	$0.69	63	0	566	0	50	0	452	0	50	0	452	0	38	15	344	136
Liriondendron tulipifera	Yellow poplar	3.62	$22.00	$2.06	$0.28	60	17	217	60	50	13	181	45	50	13	181	45	78	0	281	0
Liriondendron tulipifera (2)	Yellow poplar	3.62	$22.00	$1.73	$0.39	75	0	271	0	40	0	145	0	40	0	145	0	43	35	154	127
Platanus occidentalis	Sycamore	63.35	$0.00	$0.00	$0.00	350	77	22,172	4,857	333	58	21,116	3,643	333	58	21,116	3,643	140	50	8,869	3,167
Prunus serotina	Black cherry	2.26	$26.40	$1.75	$0.71	55	24	124	54	37	18	83	41	37	18	83	41	41	18	93	40
Quercus michauxii	Cow oak	0.05	$2.20	$0.00	$0.00	350	50	16	2	300	38	14	2	300	38	14	2	163	75	7	3
Quercus nigra	Water oak	0.90	$4.40	$1.18	$0.73	215	200	195	181	167	150	151	136	167	150	151	136	155	33	140	29
Quercus phellos (2)	Willow oak	0.23	$7.15	$1.70	$1.52	200	267	45	60	157	200	35	45	157	200	35	45	120	25	27	6
Qurcus lyrata	Overcup oak	0.06	$2.20	$0.83	$0.16	325	67	21	4	233	50	15	3	233	50	15	3	200	45	13	3
Robinia pseudoacacia (2)	Black locust	10.86	$66.00	$4.17	$1.55	50	28	543	304	43	21	471	228	43	21	471	228	33	5	358	54
Taxodium distichum	Bald cypress	1.81	$48.40	$5.36	$2.75	95	53	172	95	87	53	157	95	87	53	157	95	40	9	72	15
Ulmus crassifolia	Cedar elm	29.41	$105.60	$1.94	$0.74	15	6	441	162	13	6	373	162	13	6	373	162	9	3	265	88
				$43.08	$13.91	2,351	892	26,429	6,082	1,886	684	24,478	4,626	1,886	684	24,478	4,626	1,385	418	11,653	4,037

2 = seed stored in refrigerator for 1 year (probably had reduced viability), L = locally collected seed